ARTICLE XIV.

Observations on the Geology of the Western Peninsula of Upper Canada, and the Western Part of Ohio. By William B. Rogers, Prof. of Natural Philosophy in the University of Virginia and Henry D. Rogers, Prof. of Geology in the University of Pennsylvania. Read December 3, 1841.

To determine the exact position of the wide-spread formations of the Ohio River and the western Lakes in the general system of the Appalachian rocks, as developed in New York, Pennsylvania, Virginia and Tennessee, is a problem of much interest in the geology of the United States. It is indeed an essential preliminary to some of the most important inquiries of a scientific kind which can engage American geologists. The gradations of type in these ancient sedementary deposits, which extend, we believe, more or less to their included organic remains, and which must be first studied before we can clearly understand the physical changes that have marked the history of these strata, will not be reduced to their true laws until the continuity of the eastern and western rocks shall have been fully established.

But this determination is attended with many difficulties, since the very variations of type referred to, are often of a nature to mislead; their true value not being recognised until the investigation is nearly over. Besides these liabilities to error from changes of type imperfectly ascertained, there are others incident to the region before us where the unsupplied links between the eastern and western strata are to be sought. These are the horizontality of the rocks, the deep covering of drift which generally conceals them and the interruption of their range by the interposed waters of Lake Erie.

To compare directly the formations as they appear in the Appalachian chain with their western and northern outcrop in Ohio and New York, would not, we believe, furnish satisfactory identifications; for we already know the great alterations in type which most of them undergo in passing northward and westward under the broad bituminous coal field of Pennsylvania and Ohio. To trace them *continuously* by their lithological and fossil characters, northeastward to the Mohawk, and thence westward through New York, seemed to us to be rendered necessary by the thinning out of some formations, the coming in of others, and the suspected partial changes in the organic remains of all; and to be, in fact, the only method compatible with the caution essential in such researches.

After devoting considerable pains to a preliminary study of the formations of western New York, we resolved, if possible, to keep in view some easily recognised horizon among the strata, and by working round Lake Erie through Upper Canada and Michigan, form a junction with the rocks of Ohio.

Believing that by this procedure we have ascertained the place, approximately at least, of the rocks of parts of Upper Canada, Michigan and Ohio, we propose in the present paper to give a concise account, first, of their range from the Niagara river to Lake Huron, and, secondly, of the course of some of them from Lake Huron into Ohio.

PART I.

Of the Range of the Niagara River Rocks through Upper Canada.

Range of the Niagara Limestones.—This group of rocks, in its extension across Upper Canada, continues, as in New York, to form a great part of the escarpment of the Mountain Ridge. Its line of outcrop, thus marked, follows a nearly west course from Queenstown and the Niagara river, to the head of Lake Ontario; then bending in a rapid curve around the head of the Lake to near the foot of Burlington Bay, it strikes off in a N. N. W. direction towards Lake Iroquois, or the Georgian Bay of Lake Huron, the southern shore of which it reaches in the neighbourhood of Penetangasheen. From the Niagara river to the head of Lake Ontario, the arenaceous rocks composing the Grey-band and the other strata immediately beneath the Niagara limestone group, form, as in the neighbouring parts of New York, a low bench adjoining the base

of the main terrace, while the red shales and sandstones still lower in the series overspread the plain which stretches northwards, from the margin of this bench to the Lake shore; the whole of this series of strata, from the red shales upwards, having a gentle dip towards the south.

In passing from the Niagara river to the head of the Lake, we remarked a gradual but slight change in the lithological character of some of the strata of the Niagara limestone, the nature and degree of which will be best indicated by the annexed sketch of a vertical section of these rocks, as they are displayed in the mountain ridge at a point west of Hamilton, and upwards of fifty miles west of the Niagara river.

SECTION WEST OF HAMILTON ON THE ROAD TO ANCASTER, IN THE DESCENDING ORDER.

1. Brownish, subcrystalline, bituminous limestone.
2. Siliceous limestone of a brownish and gray colour, containing distinct courses of flint or cherty nodules.
3. Rather soft siliceous sandstone, occurring in thick slabs.
4. Hard siliceous limestones and sandstones with the vesicular structure, and hollow encrinal impressions characteristic of similar strata at Niagara Falls.
5. Lead-coloured shales and calcareous slates.

Comparing the above series of strata, in detail, with a section of the rocks at the falls and whirlpool, obtained by repeated examinations, we find that while the general character and order of succession of the principal beds remain unaltered, the calcareous and siliceous portions are more defined in their composition, the geodes are much less frequent in all the beds, and the cherty matter of the higher strata is more entirely collected into regular layers or courses. The whole group is also considerably thicker than on the Niagara river.

For some distance westward of the escarpment of these rocks, the upper plain formed by the mountain ridge is in general deeply covered with drift composed of the rolled fragments of the siliceous and bituminous limestones and sandstones, together with some of the materials of the red shale and sandstone of the formation next below; but almost entirely unmixed with the fragments of other higher calcareous rocks. Between Ancaster and Brandtsford,

about thirty miles west of Hamilton, the drift contains a gradually lessening proportion of the materials of the red shale and sandstone, while to the west and northwest of Brandtsford it ceases altogether.

In the vicinity of Paris, however, about thirty-eight miles west of Hamilton, rolled fragments of the upper group of limestones begin to make their appearance in the streams and on the surface; and, growing more frequent as we proceed westward, prove, near London, the predominant material of the drift. It need scarcely be remarked, that the N. N. W. trend of the terrace formed by the Niagara limestone would, in connexion with the admitted southerly course of the drift, give rise to the distribution of the materials here described.

Range of the Gypseous Shales.—Crossing the Niagara river in the neighbourhood of the Tonewanta, this group of strata stretches in a narrow belt some distance south of the terrace, and parallel with it. It intersects the Welland canal, and follows the course of Grand river to the vicinity of Paris. From this point these shales sweep towards the north to conform with the flexure of the mountain ridge, and passing a little east of Guelph range towards the southern end of Lake Iroquois. The gypseous shales are well exposed, in excavations for plaster, in two places on the Grand river. One of these is near the Welland canal and the other at Paris, where the top of the formation rises perhaps forty feet above the level of the stream. The shales here contain the curious hopper-shaped cavities familiarly known as a distinctive feature of the upper part of the formation in New York. They are accompanied, likewise, by the remarkable vesicular or pitted limestone, which, throughout the western counties of that state furnishes so good a guide to the gypseous beds.

Range of the Vesicular Limestone.—This is ordinarily an impure, buff-coloured, subcrystalline limestone, abounding in small lenticular cavities, having very much the shape of tabular crystals of selenite, to which they probably owe their origin. Remarkable for the permanency of its peculiar features and for its wide diffusion, this stratum has proved of the utmost service in our researches, as a safe and convenient base in establishing the super-position of the other more variable formations. Tracing the less easily identified strata by it, it served us as a grand lithological horizon from the Niagara river through Upper Canada into Michigan and Ohio.

At Paris it is associated, we have already said, with the gypsum-bearing shales. From that neighbourhood it may be traced northward to the vicinity of Guelph, in obedience to the general northern strike of all the rocks as they follow the trend of the great terrace. Westward and south-westward from Guelph the stratum very gently declines in level, in accordance with the general dip. At Beachville, on the south branch of the Thames, it is below the level of the water, the river bed, both here and at intervals for many miles north-eastward, exposing a higher limestone, and on the north branch of the same river we ascend the stream nearly forty miles northward from London before the pitted rock emerges to the surface. South of a nearly east and west line, drawn from Guelph to Goderich, rounded and weather-worn fragments of the pitted rock abound in the general drift, composed of the limestones and other beds that outcrop to the north and north-east. But in the Maitland river of Lake Huron, it is found *in situ*, well exposed with a group of overlying limestones both at Goderich and for several miles up the stream.

In no instance either among the rolled fragments or in the beds seen in place, did we detect any organic remains; but its position at the top of the gypseous shales, and its singularly well marked features, leave us in no uncertainty as to the formation to which it belongs.

Of the Rocks overlying the Vesicular Limestone in Upper Canada.—The strata which repose upon the pitted, or vesicular limestone in the western portions of Upper Canada, do not accord, exactly, with those which overlie this rock in New York. Important changes in the group take place, in fact, within the limits of that State, and other modifications will be shown to arise westward of the Niagara River. In the central counties of New York, the following strata, according to Mr. Vanuxem, intervene between the pitted rock and the Marcellus shales. 1. Hydraulic limestone; 2. Pentamerus limestone; 3. Delthyris shaly limestone; 4. Scutella limestone; 5. Oriskany sandstone; 6. Fucoides Cauda Galli beds; 7. Onondaga limestone; 8. Corniferous limestone; 9. Seneca limestone.* But in the counties west of the Genessee River the only strata not thinned away are, 1. Hydraulic limestone. 5. Oriskany sandstone. 7. Onondaga limestone. 8. Corniferous limestone, and 9. Seneca limestone.† Some of these remaining strata are much lessened in thickness,

* See Vanuxem's fourth Annual Report, General Survey of New York.

† See Hall's fourth Annual Report, General Survey of New York.

and the Oriskany sandstone is altogether absent at the Niagara River. The Rocks which have thus disappeared in going westward through New York, comprise, with the exception of the Hydraulic limestone, all the members of formations six and seven of the Appalachian System of Pennsylvania and Virginia.

In approaching the interior of the Peninsula of Upper Canada, we have evidences of a further change in the formations; the Corniferous and Onondaga limestones appearing to cease altogether before we mark the eastern shores of Lake Huron, and the Hydraulic and Seneca limestones either, likewise, disappearing, or so changing their type, as to make their recognition uncertain.

A group of limestones resting on the pitted rock about thirty miles above London, on the north branch of the Thames, seems to embrace a stratum referable to the Onondaga rock; but on the Maitland River near Goderich, where the series is well exposed, none of the formations developed east of Buffalo, excepting the well characterized pitted limestone, could be identified.

The following section of the strata exposed in the cliffs of the Maitland, conveys, we believe, a correct idea of the general order of superposition of the limestones of the south-western part of the peninsula of Upper Canada.

1. Ascending the River from the bridge near Goderich, the lowest stratum seen near the water's edge is a fawn-coloured slaty limestone of fine texture, containing hopper-shaped cavities, and a few fossils. This rock was recognised as belonging to the upper part of the gypseous shales.

2. A buff-coloured arenaceous limestone, striped with various shades. It is often merely a calcareous sandstone, of variable composition, occurring in layers from six inches to two feet thick. It contains a delthyris, but not in considerable numbers.

3. Above the last occurs an arenaceous and argillaceous rock of a yellow or buff-colour, and very rough worm-eaten aspect. It is soft, and contains geodes or nests of carbonate of lime and sulphate of strontian, the removal of which has caused its cavernous structure. This bed is several feet thick.

4. The next higher mass is a bed about two feet thick of the pitted rock of the gypsum. This is an impure buff-coloured soft limestone which breaks at right angles to the bedding. It corresponds in all respects to the rock seen at Paris, Syracuse and other places, in association with the gypseous shales. This is the highest layer exposed near the bridge; but, ascending the stream, we find excellent exposures along both its banks.

5. At the Canada Company's Mills, about two miles above the bridge, a higher set of strata appear. These consist of dove-coloured and fawn-coloured limestone, abounding in characteristic fossils, overlaid by a bluish limestone, weathering with a mealy surface, often coarser than the preceding, and sometimes slightly sparry. This also is very full of fossils.

Though the determination of the precise date of these limestones overlying the pitted rock, would supply the best link for establishing the connexion of the western and eastern strata, an approximation to it is all that we have yet been able to effect. That they constitute a new formation, not found in New York, we think is evident; but these horizontal limestones are so extensively overspread with drift, and, when, seen, expose so small a depth, as to make it impossible to find their actual contact with the Onondaga or Seneca strata; though they occur on the north branch of the Thames under circumstances that intimate their close connexion with those rocks. We cannot, therefore, assign to them their exact position; nor is it practicable to designate the neighbourhood where the Maitland limestone first appears or the Onondaga rock finally vanishes in going westward. The former originates probably east of the north branch of the Thames, while the last has an assignable thickness for some distance farther west. But if the exact horizon of the Maitland limestone cannot now be defined, there is reason, on two accounts, to place it high in the calcareous group which underlies the Marcellus shales. One motive for assigning it this position, is its obvious identity with the Sandusky limestone, the infra-position of which to the Marcellus shales can readily be shown.

That this identity exists we are persuaded from a comparison of fossils, and from actually tracing the pitted rock and Maitland limestone, from Canada round the head of Lake Erie. Another inducement for thus referring the Maitland stratum, is the affinity which prevails between its fossils and those of the Onondaga and Seneca rocks. Of the species examined, it contains in common with those formations, Atrypa affinis, also an Atrypa common at Schoharie, Strophomena lineata, a delthyris common to the Onondaga limestone and to the shales next above the equivalent of that rock in Pennsylvania, (Marcellus shales,) also Cyathophylum Ceratites and a Trilobite of the Onondaga limestone. Though these links indicate a near approximation in date, they are not regarded as proving the rock an equivalent of any of the

formations mentioned. They are the more interesting from the fact that not even this much relationship prevails between the Maitland formation and any of the strata lower than the Onondaga limestone. What seems chiefly conclusive of the high position of the Maitland rock is its identity with the limestone of Sandusky, the plane of which is but little under the horizon of the Marcellus shales.

Rocks of the Detroit River, and of the Western end of Lake Erie. Having become satisfied of the persistence of the pitted rock through Upper Canada, it became a matter of leading interest to establish the relations of it and the overlying limestones to the strata widely developed around the head of Lake Erie; regarding this as the only certain mode of ascertaining the date of the rocks of Western Ohio. Combining our own observations of the dip and range of the strata in Upper Canada, with the data recorded in the annual reports of Dr. Houghton, the State geologist of Michigan,* we became convinced of the existence of a broad, but gentle axis of elevation passing in a S. S. W. direction somewhere near the lower end of lake Huron. A slight but obvious western dip is visible on the Maitland near Goderich, and is extensively seen on the opposite or Michigan shore, southward, the whole way from near Saginaw Bay to the outlet of the Detroit River. The eastern dip from this axis is evidenced by the southern trend of the limestones, which cross the upper end of Lake Erie, between Point Au Playe and Sandusky, where the dip itself, indeed, may be detected. It is indicated by the form of the Canadian Peninsula, and strikingly by the singular line of drainage of the River Thames, which, instead of seeking a short line either to Lake Huron or Lake Erie, pursues a much longer course, as if guided by the strike of the rocks, and empties into Lake St. Clair.

Persuaded of the existence of this anticlinal axis, which passes, probably, somewhere between Goderich and the head of the Thames, we adverted next to its probable connexion with the broad anticlinal elevation of the strata in the western part of Ohio, upon which the general features of the geology of that State and Indiana mainly depend. Guided by this conjecture, we foresaw that the rocks which we had been tracing from the Niagara River, in a W. N. W. direction to Lake Huron, must experience an important change in

* See second and third Annual Reports on the Geology of Michigan.

their strike and range to the S. S. W., and that we might in all probability still meet with the pitted rock which had guided us so well in Upper Canada, on the Detroit River, and perhaps at the head of Lake Erie. Should this prove to be correct, we hoped to unite by *actual tracing* the rocks of Ohio and Michigan, with those of Upper Canada and New York. We therefore traced the formations south-westwardly, and exploring in our progress the borders of the Detroit River, and afterwards the Maumee, our anticipations were fully realized.

Rocks of the Detroit River.—The strata which border the Detroit River, both in Michigan and Canada, we readily identified by their aspect and organic remains with the beds which immediately overlie the pitted rock on the Maitland. Their exact identity, however, we were fortunate enough fully to establish by discovering the vesicular rock itself well exposed on Gros' Isle, an island at the mouth of the Detroit River, not far from the Michigan shore. The rock at this place consists of a very arenaceous cream-coloured limestone. It is seen in numerous small quarries formerly wrought, and is visible to a depth of about four feet. It abounds in the characteristic lenticular cavities, and contains geodes of sulphate of Strontian identical with those at Goderich. No organic remains seem to occur in it. The beds show an extremely gentle dip to the N. W., and their elevation above the level of the river cannot exceed eight feet.

The strata on the western side of the river are well seen in a series of quarries about one mile N. N. W. of the village of Truago or Monguagon. They are exposed in shallow excavations for several hundred yards to a depth of from five to eight feet. The prevailing rock is a light gray, somewhat sparry, very fossiliferous limestone. It is occasionally arenaceous and the weathered surfaces assume a yellowish mealy aspect. It is generally of a close texture and very pure. In the partings between the layers we detected the peculiar wavy or suture-like divisions, so abundant in another rock at the Falls of Niagara, and which we had before seen in the limestones above the pitted rock in Canada.

The rock at Truago strongly reminded us of that seen at Beachville on the Thames, and at the Mills near Goderich. An inconsiderable dip towards the north-west may here be seen.

Crossing the river here three miles broad, from Truago to Malden, on the

Canadian shore, we encounter the rock just described, in another series of quarries lying about two miles east of the river. Extensive openings, said to occupy an area of nearly forty acres, expose the strata to a moderate depth. The layers vary considerably in texture and aspect, some, when weathered, being of a yellowish tint, and arenaceous, while others are compact and comparatively pure, resembling exactly the purer variety met with at Truago. In these quarries it was difficult to establish any decided dip. If a general inclination of the beds does prevail, it is westward.

Neither at the Malden nor Truago quarries did we meet with any trace of the pitted rock, nor with any bed containing the hopper-shaped cavities seen in the limestone below the pitted rock on the Maitland. From these facts we are convinced that the Malden and Truago beds overlie the vesicular rock of Gros' Isle. They are therefore identical in position, as they obviously are in lithological character, and organic remains, with the limestones of the Maitland. These beds are highly fossiliferous, abounding in Strophomena lineata, S. rugosa, Delthyris, Atrypa, Leptæna, Cyathophillum ceratites, Favosites, Encrini, Orthoceratites, Trilobites, and several other fossils not yet specifically determined.

Rocks of the Maumee River, and of Sandusky Bay.—Near Maumee city, on the Maumee River in Ohio, we again meet with the well-marked pitted limestone, identical in all respects with that already described as occurring at Gros' Isle and Goderich. Its exposure in this position on a line drawn through Goderich and Gros' Isle, is a fact of the highest interest; for it goes to establish unequivocally, both the existence and direction of the extensive anticlinal axis which we had conjectured to pass from Upper Canada into western Ohio. The position of this important axis, is probably some distance east of the Maumee, for the rocks on that river have a visible western dip. It crosses Lake Erie most probably nearly midway between the western head of the Lake, and the chain of Islands which stretch from Point Sandusky to Point Au Playe.

Comparing the rock laid open in the quarries at Marblehead, near Sandusky Bay, with that seen at the head of the Lake, we cannot hesitate to refer them to the same formation, the opposite direction of their dips resulting from the axis above mentioned. An examination of the fossils most prevalent in the Sandusky limestone establishes, beyond a question, the identity of this forma-

tion with that of Malden and Goderich. To this last identification we attach the more importance, as the Sandusky rock, under the name of the cliff limestone of Ohio, has been of late variously regarded by geologists, some conceiving it to be the equivalent of the European carboniferous, or mountain limestone. That its closest foreign relations are to the Wenlock rocks of the English Silurian strata, and not to those of the carboniferous date, is obvious from an inspection of its organic remains alone. But there exists in Tennessee and Virginia a higher limestone not developed in either Ohio or New York, much more nearly related to the mountain limestone of Europe, to which it has been referred by Professor Troost. This rock, characterized by its oolitic structure and the beautiful genus Pentremites, appears, as we infer from some descriptions given by Troost, to be underlaid by blue limestones, identical, seemingly, with the cliff rock of Ohio.

Rocks of the Anticlinal region in Ohio.—The broad anticlinal axis which we have traced from the western side of Canada into Ohio, crosses the Ohio River somewhere in the neighbourhood of Louisville, and terminates probably in Kentucky. It imparts a general S. S. W. strike to all the strata of western Canada, eastern Michigan, Ohio, and parts of Indiana and Kentucky. The lowest formation near Lake Erie which the axis brings to the surface, is the pitted rock already traced. But that still lower formations are elevated by it more to the S. W., is apparent from the descriptions given by Dr. Locke, and other geologists, of the geology of the south-western part of Ohio.*

The cliff limestone at the base of which we place the pitted rock is there underlaid by marly shales that rest upon an extensive formation of blue limestone, well exhibited in the region of Cincinnati. These shales probably represent the gypseous shales of New York, for it is fair to conclude that so thick a mass of fine sedementary matter as they constitute on the Niagara River, can hardly have thinned away at this distance westward.

But to what formation shall we assign the blue limestones of Cincinnati? Do they correspond with the Niagara limestone next under the gypseous shales, or to some yet inferior formation? or do they belong to a new and interpolated group not met with farther east? Influenced by a certain degree of correspondence in the fossils, and by the known progressive thickening westward of the Niagara limestone, which seems to preclude a belief of its thinning out

* See first and second Annual Report of Geological Survey of Ohio.

before reaching the axis in Ohio, we are disposed to regard it and the Cincinnati limestone, which both occupy the same position under the shales beneath the pitted rock, as approximately contemporaneous. In thus viewing the limestone of Cincinnati, we regret to find our conclusions apparently at variance with those of Mr. Conrad, now decidedly the first authority in our country, in questions of Palæontology. He expresses the opinion in his last annual report, that the limestone of Cincinnati is "the equivalent or continuation of the black limestone of Trenton Falls," in New York. But to bring up a formation so low in the Appalachian series, the anticlinal axis must previously elevate not only the gypseous and Niagara strata, but the prodigiously thick groups of shales, limestones, slates and sandstones, which rest above the Trenton limestone, and which, if thus elevated, would have conferred upon Ohio, Indiana, and Kentucky a wholly different geology, mineral wealth, and physical geography from that which we now behold.

To present, in conclusion, a simple generalization of the results aimed at, respecting the range and distribution of the rocks which cross the Niagara river, let us conceive the strata forming the expanded plain bounded by the Mountain terrace, gently to decline to the S. W., in upper Canada and Ohio, while the flat but extensive anticlinal axis traverses the slope from Kentucky to the western side of Upper Canada. In these two conditions we discern the cause first of the general north-western strike of the pitted limestone, which carries it in the direction of Cabot's Head, and the Manitoulin Islands, and secondly of that long south-western strike which affects the same stratum in another outcrop, as far south as the Maumee, and expands the overlying and next subjacent rocks, in a broad zone across the Ohio river into Kentucky and Tennessee.